MARINE FISHERIES OF THE USA: MOVING FROM SINGLE-SPECIES MANAGEMENT TO A MORE HOLISTIC ECOSYSTEM-BASED APPROACH*

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INTRODUCTION[A]

The USA contains more than 152,000 km of coastline, with more than 5.4 million km^2 within its territorial waters; these waters are commonly referred to as the US Exclusive Economic Zone (EEZ). The EEZ is a political designation that begins outside state waters (~ 5 km) and extends seaward some 320 km (Fig. 1). The USA claims sovereign rights and exclusive fishery management authority over all fish, and all Continental Shelf fishery resources, within this area. Covering portions of the Atlantic and Pacific Oceans, Caribbean Sea, Gulfs of Mexico and Alaska, and islands in the western Pacific, the EEZ of the USA is the largest in the world. The enormity and importance of the marine EEZ of the USA is clear when one realizes that the EEZ is approximately 1.7 times larger than the entire USA and territorial land mass.

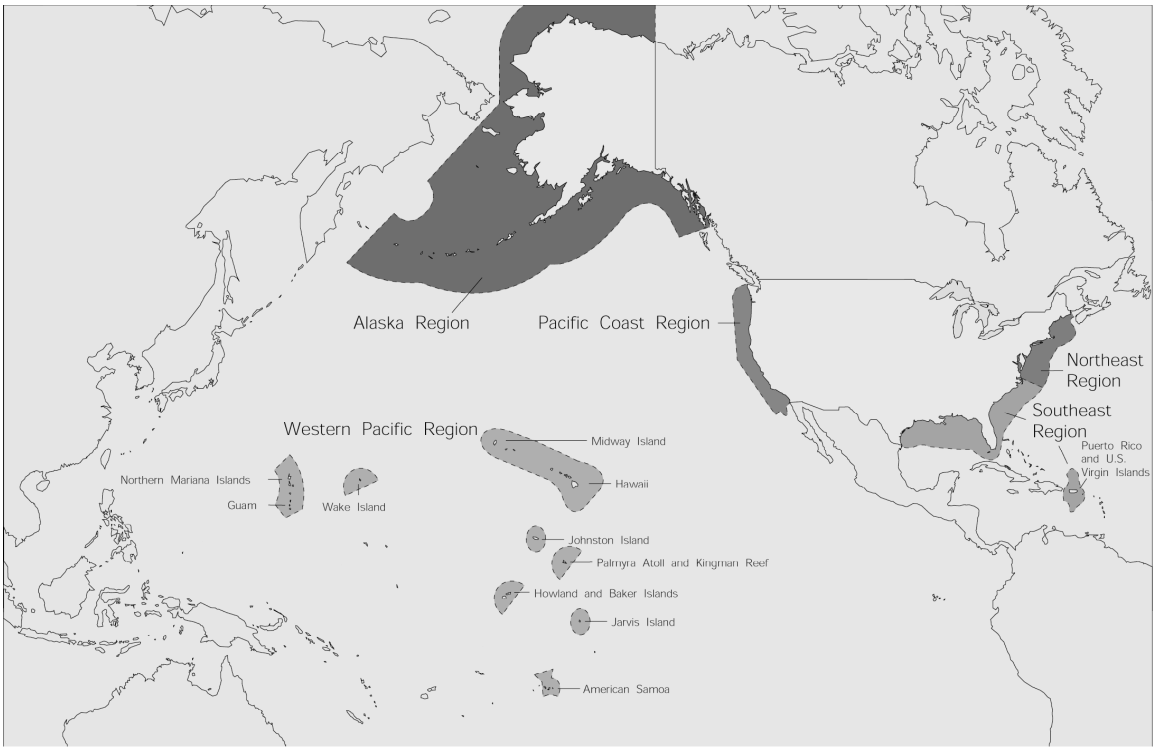

Fig. 1. Exclusive Economic Zone (EEZ) of the United States of America.

This vast marine environment provides vital environmental and economical services to the nation. As more than half of the population of the USA lives in close (90 km) proximity to the coast, pressure from recreational activities in the form of swimming, boating, and fishing continues to increase. Living marine resources (LMRs) directly and indirectly support extensive industries in the USA. Commercial and recreational fishing significantly contributes to the economy of the nation and constitutes a major source of employment to many coastal communities. In 2000, for instance, 20 billion kg of LMRs were estimated at US$3.5 billion from commercial landings alone by USA fishers (where 'billion' signifies one thousand million). Additionally, it has been estimated that recreational fishermen took 76 million fishing trips and caught 429 million fish (NMFS 2002).

FISHERIES MANAGEMENT IN THE USA

Maintenance of sustainable fisheries with this ever-increasing demand on the resources represents an extremely complex and often controversial challenge. The National Marine Fisheries Service (NOAA Fisheries), part of the US Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), has been entrusted with the nation's LMRs and is the agency responsible for science-based conservation and management of these resources. When NOAA was established in 1970, one of the primary missions of the agency was to develop the nation's underutilized fisheries. Unfortunately, much has changed since the 1970s, as the past three decades have seen overcapitalization of the nation's fishing fleets and continued decline of fish stocks.

While the *Marine Mammal Protection Act of 1972* and *Endangered Species Act of 1973* indirectly may provide protection to some fish stocks, the landmark legislation governing fisheries management in federal waters of the USA was crafted in 1976 with the passage of the *Magnuson–Stevens Fishery Conservation and Management Act* (herein known as the *Magnuson Act*). The *Magnuson Act* has since achieved the stated goals of nearly eliminating foreign fishing from the US EEZ and developing domestic fisheries. The *Magnuson Act* also created eight Regional Fishery Management Councils (FMC) throughout the country who, acting on behalf of the federal government, are charged with conserving and managing fisheries resources under their regional jurisdiction. This process involved developing individual fishery management plans (FMPs) and proposing regulations governing the individual species. The Councils comprise scientists, fishing industry representatives, consumer and environmental organizations, the general public, and political representatives. Although this diverse membership ensures that all segments of fisheries participate in, and advise on, the content of the FMPs, it can sometimes be contentious and inefficient because of the very different mindsets of these groups. The *Magnuson Act* also requires the Councils to achieve a balance between science and economics. This balance has proven to be elusive at times and the Councils often are criticized by those that feel that the FMP is weighted much more to one segment than the other (e.g. economics *v.* conservation). The national standard for fishery conservation and management strives for measures to prevent overfishing, yet equally strives for extracting the maximum sustainable yield (MSY) from each fishery. Since the passage of the *Magnuson Act* in 1976, decisions of the Councils have not always achieved this balance nor reversed the decline of many fish stocks; this failure has been due to competing interests, political pressure, and unreliable scientific data.

Realizing this continued decline, Congress amended the *Magnuson Act* and passed the *Sustainable Fisheries Act* (SFA) in 1996. The SFA noted that certain stocks of fish continue to decline and that their survival is threatened if fishing pressure is not reduced and important habitat is not protected. Hence, the SFA required the FMCs to develop FMPs that minimized bycatch and disturbance to important habitat caused by fishing gear, to end over-fishing, and to devise a plan to rebuild overfished stocks. For the first time since the passage of the *Magnuson Act* in 1976, the SFA amendments make the duty to protect fish stocks and to eliminate overcapitalization and over-fishing an enforceable legal obligation.

It is clear that one of the primary objectives of USA fisheries management is to develop sustainable fishery harvests that minimize the risk of overfishing. This has been a very difficult goal to realize, because many stocks are managed "at the edge" as a result of heavy social and economic considerations to maximize harvest wherever and whenever possible. In this management scenario, imprecision in stock assessments can lead to population crashes in the fishery. Therefore, comprehensive and accurate data on landings and fishery-independent monitoring surveys are of paramount importance. Output controls that attempt to limit the number/weight of a given species that can be harvested (e.g. total allowable catch) are based on analyses of these data. Collection, analysis, and interpretation of all the information necessary (Fig, 2) to estimate a stock size and estimate the amount of fish that can wisely be harvested fluctuates annually and is subject to a considerable amount of uncertainty.

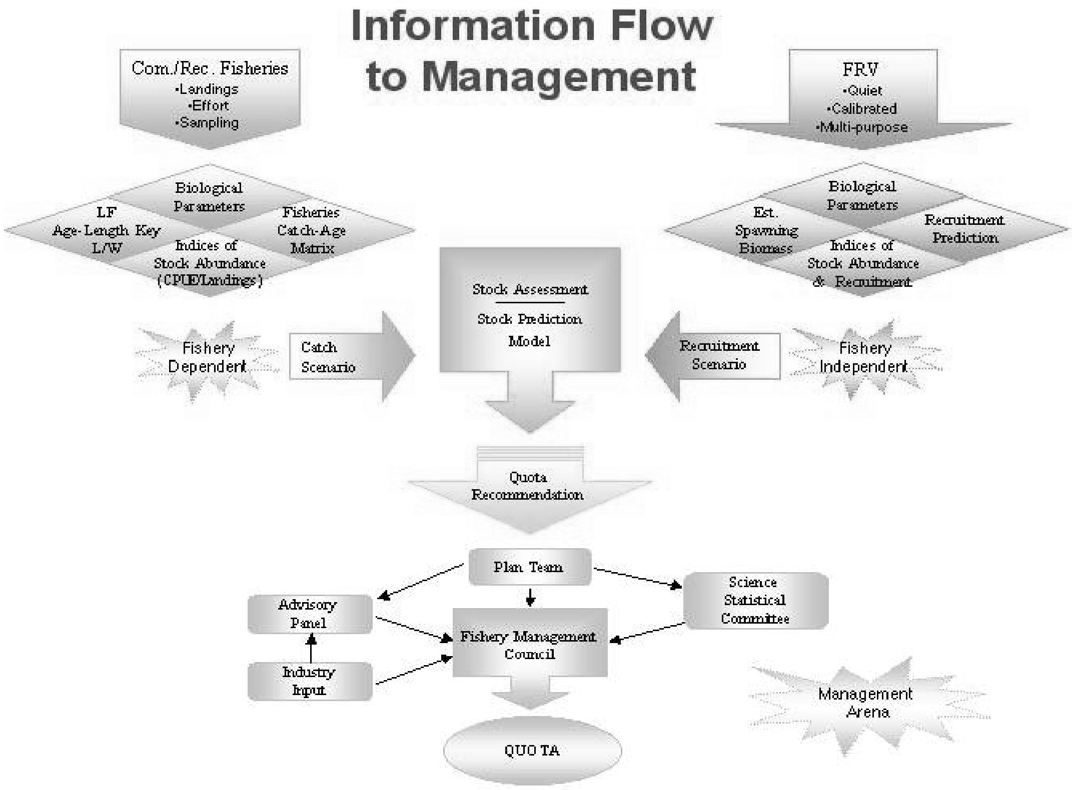

Fig. 2. The flow of scientifically sound information and data to support fishery conservation and management.

Abundance estimates from research surveys and virtual population analysis (VPA) are used to set catch quotas in the USA. VPA relies upon commercial catch-at-age data to reconstruct past stock abundances and makes several assumptions. Abundance estimated from research surveys can be highly variable, partly because gear efficiencies may change from year to year. Often, trends in abundance as determined by VPA do not track those derived from research surveys. Population abundances can be overestimated and fishing mortality underestimated because of uncertainty. These discrepancies cause ill-supported management decisions and can lead to fish stock collapse as witnessed in the Atlantic Ocean off Canada for the cod fishery.

What has emerged through these many fluctuations and uncertainties is a complex set of evolving regulations and amendments that make monitoring, conducting, and enforcing fisheries in the USA difficult for everyone. For instance, in 1996 alone, 855 regulatory actions were processed through the Federal Register to implement and amend rules and actions for domestic fishing in the USA. What ultimately occurs is a mixture of seasonal closures, gear restrictions, and limits on the number of fishing days.

Present interest in simplifying regulations and better protecting fish stocks and their habitat through the use of marine protected areas (MPAs) reflects dissatisfaction with conventional fishery management. Ecosystem-based approaches in fisheries management that take into account unintended consequences of fishing (bycatch and habitat degradation), important interactions among various species, and uncertainty of stock assessments may be an attractive supplement to the management of single species. Executive Order 13158: Marine Protected Areas, implemented in 2000, recognizes that reducing effort and fishing mortality to an acceptable level in order for stocks to rebuild *may* require areas to be set aside, free from extractive uses, in order to provide insurance against natural fluctuations and scientific uncertainty. In the 1990s, several area-based Federal Fishery Management Zones were designated to restrict specific types of fishing gear or eliminate all extractive uses in order to provide added protection to important habitat and spawning aggregations, reduce fishing mortality, conserve biodiversity, and rebuild fish stocks.

In 1996, 39 FMPs guided the management of 727 species. NOAA Fisheries found that 86 species (12%) were overfished, 10 (1%) were approaching overfished status, 183 (25%) were not overfished, and the status of the remaining 448 species (62%) was unknown. Clearly, today's individual-stock and single-species management appears ineffective at times and new approaches need to be explored. The case studies that follow describe this new paradigm: area-based management that reduces fish mortality, bycatch, habitat destruction, user conflicts, and the consequences of stock-assessment uncertainty. Instead, these areas rely on the precautionary approach of areas set aside to act as insurance against unforeseen climatic events, poor recruitment years, and scientific uncertainty.

CASE STUDY: CAPE CANAVERAL, FLORIDA[B]

Two unintended reserves were created starting in 1962 at Cape Canaveral, Florida, when two estuarine areas in the Merritt Island National Wildlife Refuge (MINWR) were closed to all public access for security of the John F. Kennedy Space Center. This action created the oldest and, until 1999, the largest no-take reserve in North America. Johnson *et al.* (1999) reported on studies conducted in the 1980s, which showed that three areas without fishing had significantly higher average fish biodiversity and more abundant and larger exploited-fish species than three surrounding areas with fishing. Standardized catch-per-unit-effort (CPUE), adjusted to account for habitat differences between areas (i.e. depth, salinity, and submerged aquatic vegetation), showed that fishing was the primary factor accounting for differences between areas among exploited species. CPUE in closed areas for important gamefishes were 12.8 times greater for black drum (*Pogonias cromis*), 6.3 times greater for red drum (*Sciaenops ocellatus*), 2.3 times greater for spotted seatrout (*Cynoscion nebulosus*) and 5.3 times greater for common snook (*Centropomus undecimalis*).

The effects of closed areas on surrounding recreational fishing were reported by Roberts *et al.* (2001) on the basis of an analysis of International Gamefish Association (IGFA) world records from 1939 through 1999. Tested were hypotheses predicting that a significantly higher concentration of world records would occur near reserves than elsewhere in Florida and that disproportionate increases would occur after areas were closed to fishing. An alternative hypothesis was that since a smaller area was available to fishing, fewer world records would occur around Cape Canaveral. Data supported the two primary hypotheses for all three year-round resident gamefishes: 62% of all 39 Florida world records for black drum, 54% of 67 for red drum, and 50% of 32 for spotted seatrout were reported within 100 km (60 miles) of reserves (~13% of the Florida coast). As predicted, the proportion of records around closed areas also increased significantly after areas were closed to fishing. In addition, common snook, which was not reported from the Cape between 1959 and 1962, before areas were closed to fishing, had became established by the 1980s, although only 4 of the 84 world records from Florida were reported from the Cape.

Some of these records were undoubtedly the result of spillover, the movement of individuals from protected areas into surrounding areas. This conclusion is supported by tagging studies showing movements of fishes into and out of protected areas (Johnson *et al.* 1999; Stevens and Sulak 2001). It is also possible that greater reproduction of large individuals in reserves contributed to a larger population base from which some individuals survived to attain large size. This possibility is supported by Johnson and Funicelli (1991), who demonstrated that reproduction occurred at the Cape.

Over the study period, Florida's human population increased from 5 million in 1960 to 16 million in 2000. Recreational angling presumably increased in similar proportion. To compensate for increased fishing pressure, Florida has enacted many conservation measures to reduce total fishing mortality. These measures include the gradual elimination of commercial fishing by prohibiting the sale of sport fishes and a statewide commercial net ban in 1995. Florida has also regulated sport anglers by closed seasons, daily bag limits, and minimum and (for some species) maximum size limits. Because most conservation measures apply statewide, they alone are unable to explain the high concentration and increases in records around Cape Canaveral. The net ban, for example, certainly reallocated landings from commercial to sport anglers, but cannot explain the pattern of world records around the Cape which began increasing years before the net ban. The habitat in MINWR is excellent for sport fishes but the possibility that it was somehow unique, independent of the closed areas, does not explain the significant record increases after areas were closed to fishing. The simplest explanation for the data is that no-fishing areas reduced total fishing mortality and led to more world records in surrounding areas. The results from this case history confirm predictions that no-take reserves can support sustainable fishing for multi-species, especially when used in conjunction with other fishery conservation measures.

CASE STUDY: FLORIDA KEYS NATIONAL MARINE SANCTUARY

On 1 July 1997 the Florida Keys National Marine Sanctuary (FKNMS) established 18 no-take

Sanctuary Protected Areas (SPAs) and one 10 nmiles[2] no-take Ecological Reserve in the Western Sambo region of the lower Florida Keys. An additional four SPAs were established to limit fishing to recreational trolling only. Since then, annual underwater visual surveys have been conducted to assess changes in reef-fish populations in areas open and closed to fishing. Extensive baseline data were collected between 1994 and 1997 from reefs eventually closed to fishing, as well as from reference reefs left open to fishing.

Preliminary data show that mean density (number of individuals per sample) of populations of important exploited reef species have increased significantly at protected reefs and were higher than on fished reefs. Yellowtail snapper (*Ocyurus chrysurus*), for example, supports the most important reef-fish fishery (Fig. 3) and was the first species to show a significant population response to protection from fishing.

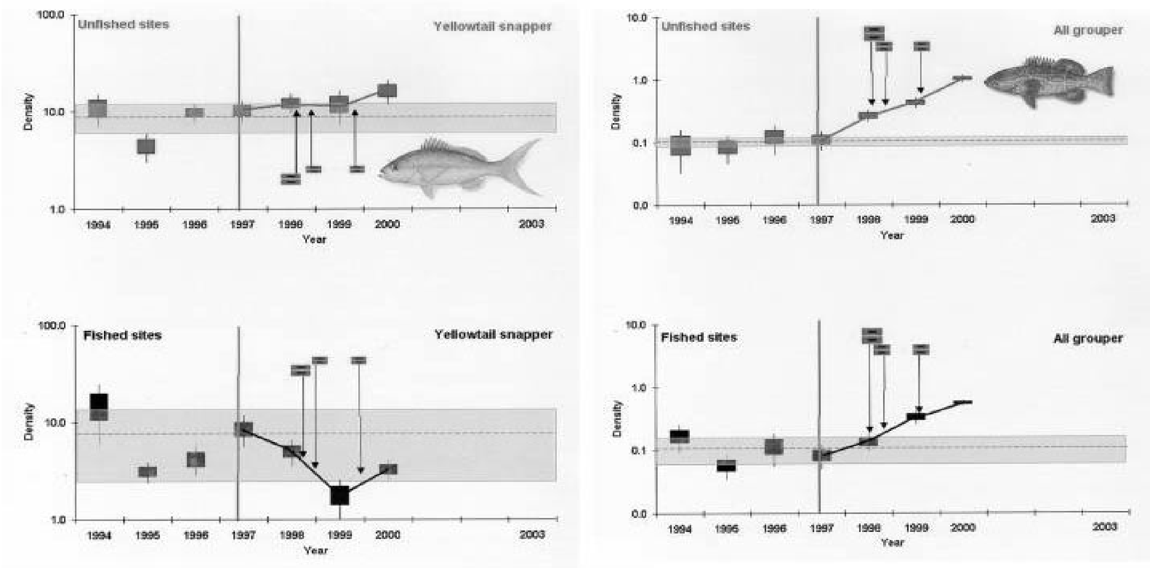

Fig. 3. Density trends for yellowtail snapper (left) and exploitable grouper (right) from Florida Keys reefs open to fishing (bottom) and protected from fishing (top). Vertical bars: 95% confidence interval. Boxes: ± 1 standard error. Bold vertical line: initiation of no-take protection in 1997. Dashed line: 1994–97 mean density. Shaded band: 1994–97 annual baseline performance based on the 95% confidence intervals (projected beyond 1997 to show predicted density ranges if no changes occurred). Hurricane symbols: hurricanes on the lower Florida Keys in 1998 and 1999. From Bohnsack *et al.* (2001).

Mean density initially was significantly higher in no-take zones than in fished sites, but it increased significantly in no-take zones compared with the 1994–97 baseline, while no significant changes occurred in fished sites. The mean density of combined exploited grouper (Serranidae) species has increased both at fished reference reefs and in no-take zones since 1997 and currently is approximately an order of magnitude higher than that during the baseline period. Densities in no-take zones, however, have increased faster that in fished reference areas, especially in 2000 and 2001, the third and fourth year following protection. Mean density of gray snapper (*Lutjanus gresius*) was higher in no-take zones than in fished reference areas every year since 1997. In contrast to exploited species, two species not targeted by fishing show different trends. Striped parrotfish (*Scarus croicensus*), a small herbivore, and stoplight parrotfish (*Sparisoma viride*), a large herbivore, showed no significant increases in abundance since the closure of reefs to fishing. High concordance in mean density was observed each year in both fished and unfished areas over the study period. Years with drops or increases in mean density were observed on both reference and protected reefs.

In summary, since no-take protection was initiated in 1997, several exploited species have shown significant increases within no-take zones in density and average size of exploitable-phase individuals, while no significant changes have been observed for non-exploited species. For two exploited species, average size and density of exploitable-phase individuals also increased significantly in fished reference areas, but the magnitudes of these increases were still significantly lower than the increases observed in no-take zones. These results support the necessary predictions of marine reserve theory that population abundance and size of exploitable fish will increase within areas protected from extraction. Because the total area of no-take zones is only approximately 0.5% of the FKNMS, measurable effects on total fishery yield are unlikely; however, edge effects, a concentration of fishing around reserve borders, have been noted.

In 2001, two ecological reserves covering a combined area of 151 nmiles^2 were established in the Tortugas region, west of the Florida Keys. In addition, Dry Tortugas National Park has approved the creation of a 46 nmiles^2 Research Natural Area that will offer additional habitat and population protection in an area contiguous with ecological reserves in the FKNMS. Although it is premature to make any conclusions about changes in the Tortugas, the region will be periodically monitored for changes.

CASE STUDY: CLOSED AREAS ON GEORGES BANKC

The rich fishing grounds off New England played an essential role in the early economic development of the USA. The bountiful resources of Georges Bank, in particular, long supported fishing communities in this region. By the beginning of the 20th century, decline of some important resource species such as Atlantic halibut had already occurred. With the advent of distant-water fleets operating off the New England coast in the early 1960s, however, a pattern of sequential depletion of groundfish and small pelagic species was established, leading to a series of management measures by the International Commission for Northwest Atlantic Fisheries intended to stem overfishing of these valuable resources (Fogarty and Murawski 1998). As part of this effort, seasonal closures of portions of Georges Bank were implemented in 1970 with the objective of protecting spawning aggregations of haddock (Halliday 1988; Murawski *et al.* 2000). In 1994, year-round closure areas were established on Georges Bank based on these earlier seasonal sites, and an additional closure area off southern New England, designed to protect yellowtail flounder, was based on earlier seasonal closure areas for this species (Fig. 4).

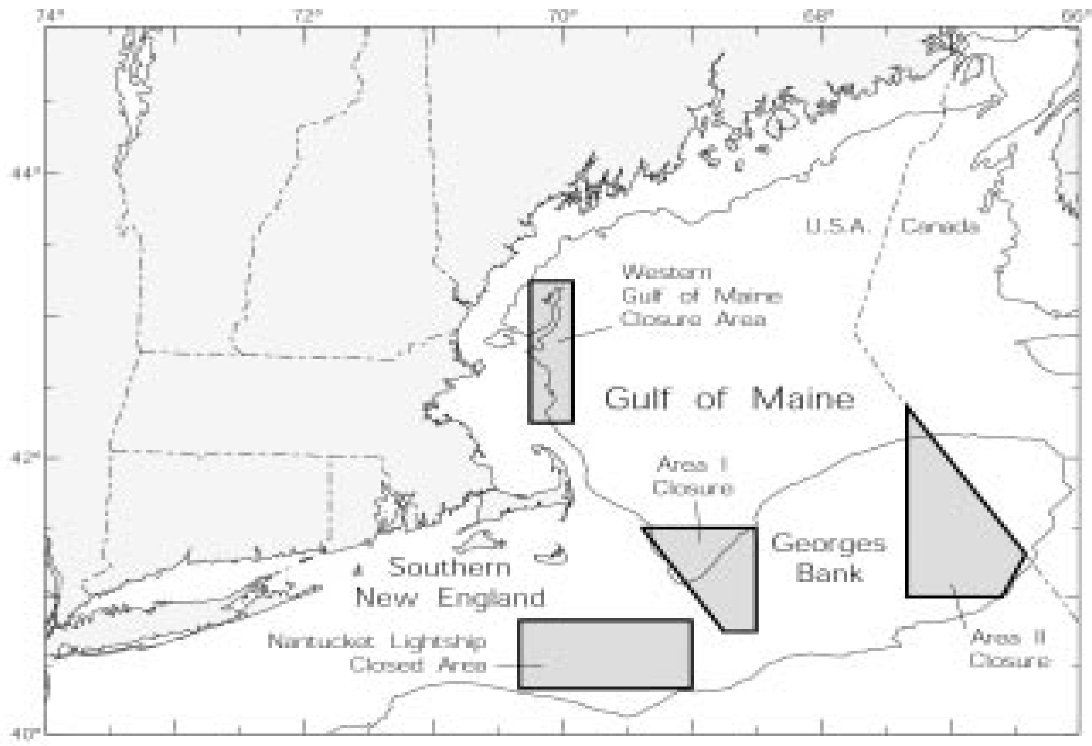

Fig. 4. Location of year-round closed areas off New England

These three areas encompassed 17,000 km². Use of fishing gears capable of retaining groundfish, including trawls and scallop drags, was prohibited in the closed areas. Closure areas were subsequently adopted in the western Gulf of Maine to protect groundfish resources and in the mid-Atlantic Bight to protect scallops.

Groundfish resources

Establishment of the year-round closed areas on Georges Bank and southern New England coincided with sharp reductions in fishing effort (days-at-sea), mandated under Amendment 5 of the Northeast Multispecies Groundfish Management Plan, and with other measures such as mesh regulations and minimum legal size limits; this complicated efforts to determine the effects of the closures. A 41% decline in days-at-sea was effected over the first three years of this management regime; during this period, the fishing mortality rates of cod, haddock and yellowtail flounder declined by 62%, 68%, and 88% respectively (Murawski *et al.* 2000). The imposition of the closed areas presumably accounts for the enhanced reduction in fishing mortality relative to the reductions in fishing effort (Murawski *et al.* 2000). The lower CPUE (and overall removals from the stocks) in the open areas relative to the closure areas are a major contributor to the reduction in fishing mortality rates for cod and yellowtail flounder in particular.

The major groundfish stocks on Georges Bank have responded differentially to these management measures. Sharp reductions in overall exploitation rates for Atlantic cod since 1994 have resulted in a 50% increase in spawning-stock biomass (Fig. 5a). This increase in biomass is attributable to increases in mean size accompanying increased survival rates for age classes vulnerable to the fishery. No evidence of increased recruitment (numbers of age-1 Atlantic cod) has been noted. In contrast, spawning-stock biomass of haddock on Georges Bank has increased by 400% since 1994, reflecting both improved recruitment and increased mean size of adults (Fig. 5b). The 1998 year class of haddock is the largest in two decades (although still lower than historical median recruitment levels. For yellowtail flounder, dramatic increases in recruitment since 1994, coupled with increased mean size in the adult population, have resulted in an 800% increase in spawning-stock biomass (Fig. 5c).

The differential response of cod, haddock, and yellowtail reflects differences in distribution and seasonal movement patterns relative to the closed areas and differences in life-history characteristics. Closed Area I (see Fig. 4) provides year round protection for cod and particularly for the western spawning component of haddock (Brown *et al.* 1998). Closed Area II provides effective protection for cod and haddock during winter-spring; however, during summer and autumn, these species are distributed in deeper, colder waters, including the Northeast Peak of Georges Bank under Canadian jurisdiction. Harvesting of cod and haddock is permitted in Canadian waters only during the second half of the year. Yellowtail flounder are comparatively sedentary, with significant distributions on both sides of the international boundary throughout the year. Recent studies employing monthly trawl surveys indicate some seasonal movements especially associated with closed area II.

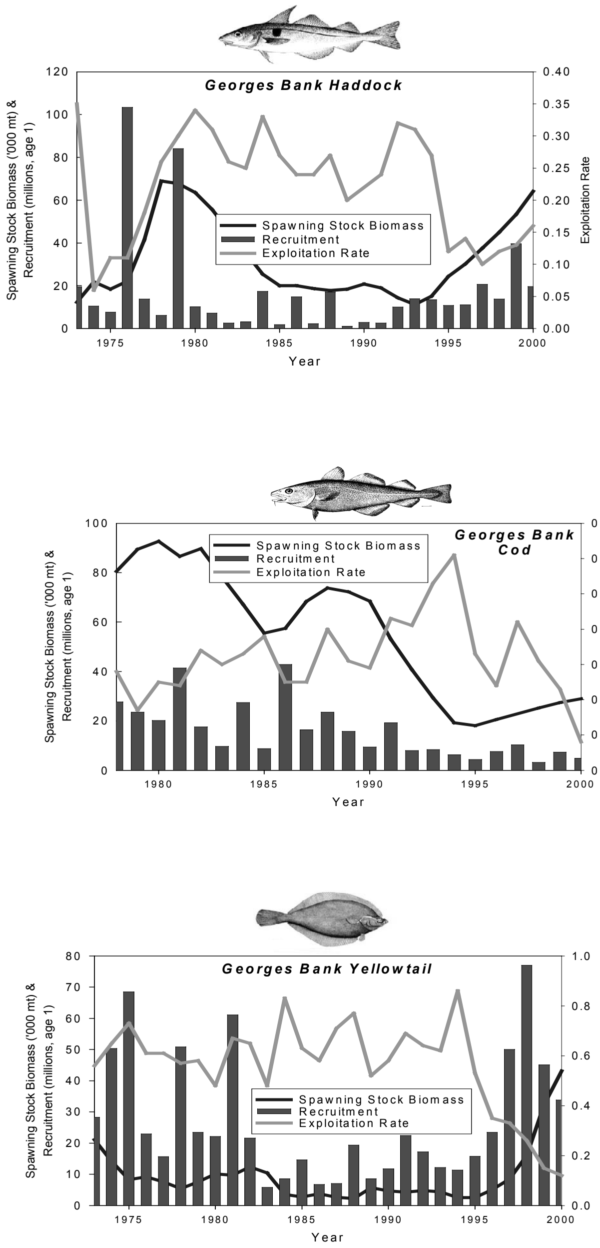

Fig. 5. Trends in exploitation rates, recruitment (age-1 fish) and spawning-stock biomass for (*a*) Atlantic cod, (*b*) haddock and (*c*) yellowtail flounder.

Sea scallops

The effects of implementation of closed-area management strategies on Georges Bank and in southern New England need to be considered in concert with other management strategies designed to reduce overall levels of fishing effort. Although the year-round closed areas in this region were established specifically to meet groundfish management objectives, these closures had important incidental benefits for scallop resources.

The Atlantic sea scallop *Placopectin magellanicus* supports the second most valuable fishery (after the American lobster) in New England. By the mid 1990s, the scallop resource on Georges Bank had been sharply depleted in the boom-and-bust pattern characteristic of this fishery. Prohibition of scallop fishing within the areas on Georges Bank that were closed to groundfish in 1994 therefore met with little resistance from scallop fishers.

Resource surveys conducted by the Northeast Fisheries Science Center have shown that sea scallop biomass within the closed areas on Georges Bank has increased 16-fold since 1994 (Fig. 6); an approximate 4-fold increase has been observed in the open areas during this period. Dramatic increases in mean size of scallops in the closed areas and widespread strong settlement in 2000 have accounted for the overall increase in biomass for this species.

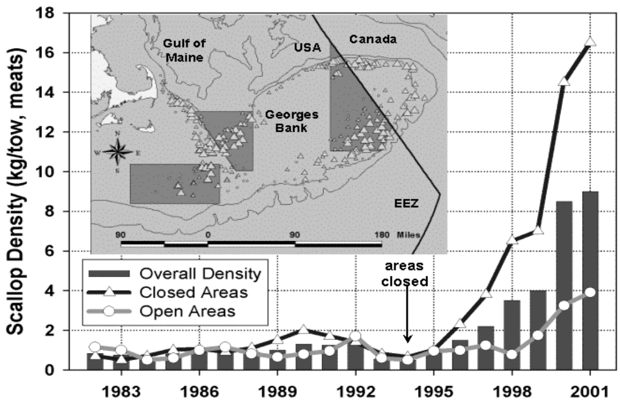

Fig. 6. Trends in sea scallop density in open areas, closed areas, and the total area on Georges Bank.

Dispersal of sea scallops is predominantly in the larval phase; juveniles and adults are relatively sedentary although they are capable of movement. This species is therefore particularly well suited to protection by closed-area management. Hydrodynamic–biological models indicate that the closed areas on Georges Bank are self-seeding for scallops and also that the closed areas potentially contribute recruits to the open areas. An understanding of this spill-over effect is essential to predicting the potential benefits of the closed areas to the scallop fishery.

CASE STUDY: THE COWCOD CONSERVATION AREAS OFF SOUTHERN CALIFORNIA[D, E]

For the past several decades, more than 52 species of rockfishes (genus *Sebastes*) and the lingcod (*Ophiodon elongatus*) formed the basis of very large recreational and commercial fisheries along the Pacific Coast of the USA and Canada. With a recreational value estimated in the billions of dollars and commercial value in the many tens of millions of dollars, these fisheries helped support the economic health of many coastal communities.

Today, there is abundant evidence that these fisheries are in severe decline (Ralston 1998; Pacific Fishery Management Council 1999). At least three important events have combined to drastically reduce the populations of many of these species. First, overfishing has substantially reduced the numbers of subadults and adults. Many of these species have extreme life spans (to 100+ years), are slow to mature (3–20 years of age), and reproduce every year of their adult life (Love *et al.* 2002). Consequently, overharvesting likely has also reduced the number of young rockfishes being produced. Second, in the past twenty-five years, adverse oceanic conditions have contributed to increasingly poor survivorship of young stages of these fishes, again leading to fewer juveniles to replace those that are caught (Roemmich and McGowan 1995; Love *et al.* 1998; Moser *et al.* 2000). Third, there is evidence that some fishing gear, particularly some types of bottom trawls, can be destructive to seafloor habitats (Collie *et al.* 1997; Jennings and Kaiser 1998). This, too, could diminish the survival of both young and adult rockfishes and lingcod.

A number of these species are currently declared overfished by NOAA Fisheries. By way of example, the bocaccio, *Sebastes paucispinis*, was once arguably the most valuable rockfish in California waters. Throughout the twentieth century, recreational and commercial fishermen took millions of individuals, and it was among the most important species at virtually all ports. It was quite likely the dominant species over most deep-water (100–250 m) rocky habitats. A recent assessment estimated that the bocaccio population off California now is 12% of the 1970 spawning output and 16% of 1970 total biomass. It will take 20 to 25 years to rebuild this population to 40% of historic levels (MacCall 2003).

Cowcod are one of the largest West Coast rockfishes, growing to 100 cm (39 inches). Although never as abundant as bocaccio, commercial passenger fishing vessels (CPFV) often targeted this species. Historically, they were most abundant in the waters around some of the islands and offshore banks of the southern California Bight (MacGregor 1986; Moser *et al.* 2000; Butler et al. 2003). Cowcod biomass presently is estimated to be about 7% of unfished biomass; it will likely take close to 90 years to rebuild to this population to 40% of historic levels (Butler et al. 2003).

It is clear that abundance of both species, estimated from CPUE from creel censuses of CPFVs, was highest during the 1970s, declined in the 1980s, and had declined further by 1999 (Fig. 7). Mean annual CPUE for bocaccio in the 1970s was roughly twice that of the 1980s and 20 times that in 1999. A similar decline in mean annual CPUE occurred for cowcod.

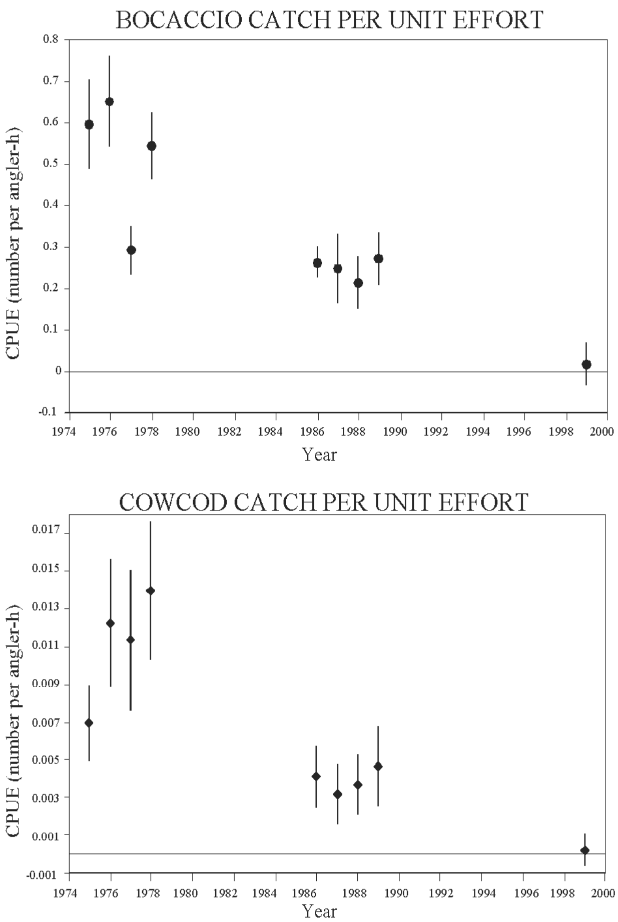

Fig. 7. Annual mean catch per angler-hour (CPUE) of bocaccio and cowcod taken in the southern California commercial passenger fishing-vessel fishery, 1975–78, 1986–89, and 1999 (vertical bars are estimated standard error).

The Pacific Fisheries Management Council (PFMC), acting on behalf of the federal government as administered by NOAA Fisheries, is responsible for assessing and managing most groundfish populations from Washington to California and, in the past few years, has acknowledged that many are in severe trouble. By 2000, it was apparent that measures previously considered radical were necessary if some rockfish stocks were to recover off California. As a first step, beginning in 2001, the PFMC eliminated directed fishing opportunities for cowcod in southern California. Retention of cowcod was prohibited for all commercial and recreational fisheries. And, in an unprecedented effort to protect cowcod from incidental harvest, the Council established two Cowcod Conservation Areas (CCAs) in the Southern California Bight (Fig. 8). These two areas, encompassing about 14,750 km^2 (4,300 nautical miles^2), include key cowcod habitat and areas of relatively high cowcod catches. Fishing for all groundfish is prohibited year-round within the CCAs, with the exception that nearshore rockfish, cabezon, and greenling may be taken from waters where the bottom depth is less than 36.6 m. It is important to note that these closed areas protect far more than cowcod, serving to protect at least 50 other species of rockfishes and lingcod.

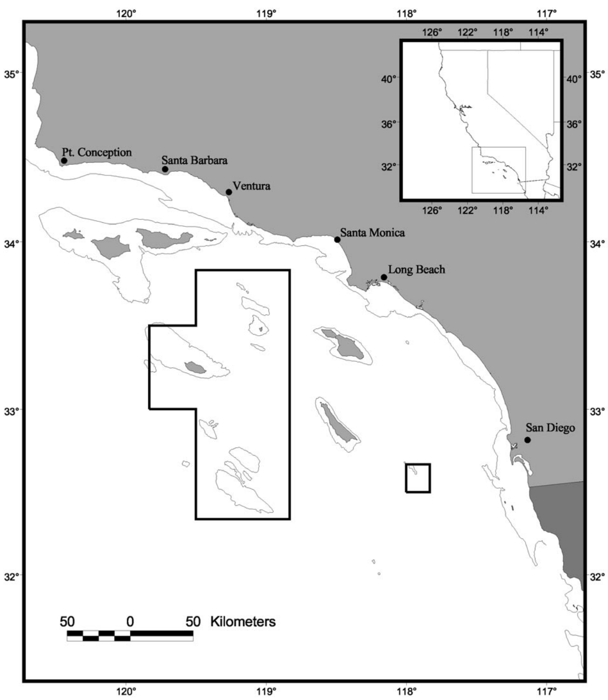

Fig. 8. Location of Cowcod Conservation Areas in the Southern California Bight.

Assessment of the effectiveness of these closures is underway. Baseline population surveys are being conducted inside and adjacent to these closures and the protocol for follow-up monitoring is being established. Without these, it will be impossible to determine what, if any, changes occur in rockfish and lingcod populations either within or outside these refuges.

Adult rockfish and lingcod populations, in particular, are very difficult (or impossible) to accurately appraise with traditional survey methods such as the use of surface-based trawl gear. This is because trawl nets are virtually excluded from high-relief rock outcrops, which are precisely the habitats where many rockfishes and lingcod (and often the larger individuals of the population) are most abundant (Yoklavich *et al.* 2000). Consequently, alternative techniques are necessary to track the recovery of these fishes.

In collaboration with researchers from University of California Santa Barbara, Moss Landing Marine Laboratories, and California Department of Fish and Game, and with additional funding from NOAA National Undersea Research Program, NOAA Center for MPA Science, and the David and Lucile Packard Foundation, we are conducting underwater surveys of rockfish populations and their associated habitats over rocky banks inside and in the vicinity of the newly established Cowcod Conservation Areas using *in situ* video-transect techniques and direct observations from an occupied research submersible. We are using quantitative transect techniques to estimate abundance and fine-scale distribution of habitats and fish density, size structure, and species composition and richness. These variables will be analysed relative to depth and microhabitat, and compared between areas in and out of the MPA. Digital, georeferenced maps of the seafloor, acquired from side-scan sonar, multibeam bathymetry, seismic reflection and other past geophysical surveys, are being used together with past and recent groundfish catch-and-effort records to identify and select sites with appropriate habitats. We strongly believe that the success or failure of the MPA will depend on the timely and accurate assessment of its effectiveness. But, before we can assess whether the CCAs are effective in rebuilding these fish populations, we need to (*1*) accurately estimate the abundance of rockfishes and lingcod near the onset of MPA establishment, (*2*) identify the locations of remnant populations of these target species outside the CCAs and evaluate these sites for additional protection, and (*3*) appraise the status and use of the protected benthic habitats by target fish species currently designated as severely overfished.

Our study sites and survey protocols will serve as the foundation for a long-term monitoring program for the CCAs as well as a model for monitoring future deepwater MPAs, which are currently being developed under California's *Marine Life Protection Act of 1999* and are being considered by the Pacific Fisheries Management Council's Marine Reserve Advisory Panel (Parrish *et al.* 2000). Results of our studies will also be particularly useful in producing more accurate stock assessments for those fishes associated with high-relief rock habitats, especially those southern California species that presently are not assessed. This information is essential in monitoring the effectiveness of those programs designed to rebuild these overfished stocks.

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